CONODONT BIOSTRATIGRAPHY OF THE UPPER PHOSPHORIA FORMATION (UPPER PERMIAN)

A THESIS

Presented in Partial Fulfillment of the Requirements
For the Degree Bachelor of Science

by

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INTRODUCTION

The first studies of the Phosphoria Formation were initiated by the U. S. Geological Survey in the early part of this century to investigate the reserves of phosphate for agricultural purposes (Richards & Mansfield, 1914). Subsequently numerous investigations have explored stratigraphic relationships, lithologic sequences, various economical reserves, and physical and chemical factors that affected deposition. Biostratigraphic work in the Phosphoria Formation has been slow and difficult because few diagnostically reliable fossils have been found in these lithic units. Absence of fossils in this region is attributed to limited migration or unfavorable environments by McKee and others (1967a,p. 32). A concise summary of the results of most of these works is presented in U. S. Geological Survey Professional Paper 313 by McKelvey and others (1959), Sheldon (1963), and Yochelson (1968).

This report is concerned with determining the age of a part of the Phosphoria Formation by the biostratigraphic correlation of conodont faunas. Conodont studies of Upper Permian rocks in the northern Rocky Mountain region and in other geographic locations that are useful for identification and correlation purposes include Croft (1972), Marcantel (1975), Clark and Ethington (1962), Clark and Behnken (1971), and Behnken (1975).

This study is based on 22 bulk samples collected by Dr. J. Collinson from five localities in the Phosphoria, Park City, and Shedhorn Formations. I processed 19 of these samples for conodont recovery but only 7 were productive. These yielded a total of 665 elements representative of four genera, all of which have been previously described. Methods of sample preparation were similar to those presented in Lindström (1964, Chapter 11), including magnetic and heavy liquid separation of the residues. (Table 1). Thin sections of the samples were prepared for lithologic study. (Appendix).

ACKNOWLEDGEMENTS

The author would like to express her gratitude to Dr. James Collinson for his suggestions, patience, and encouragement throughout all phases of this study. Discussions with Dr. K. O. Stanley, Dr. Bruce Wardlaw, and Dave Shatzer were both beneficial and stimulating. Technical assistance from Mr. R. Markley, Mr. J. Franklin, and Mr. R. Wilkinson was greatly appreciated by the author.

LITHOSTRATIGRAPHY

The Phosphoria Formation extends throughout the northeast Great Basin and northern Rocky Mountains of southeast Idaho, southwest Montana, western Wyoming, and northern Utah. The sequence thickens toward the west and thins eastward where it intertongues with its lateral equivalent, the Park City Formation. The Shedhorn Sandstone interfingers with the Phosphoria sequence from the north. These formations are all of Permian age, ranging from Late Leonardian to post-Wordian(?) (McKelvey and others, 1959).

The Phosphoria Formation unconformably overlies the Pennsylvanian Tensleep Sandstone and the Pennsylvanian Wells Formation to the west. It is overlain by the early Triassic Dinwoody Formation throughout most of its lateral extent (Sheldon, 1963, pp. 61-64). The western miogeo-synclinal deposits are complexly folded and thrusted eastward.

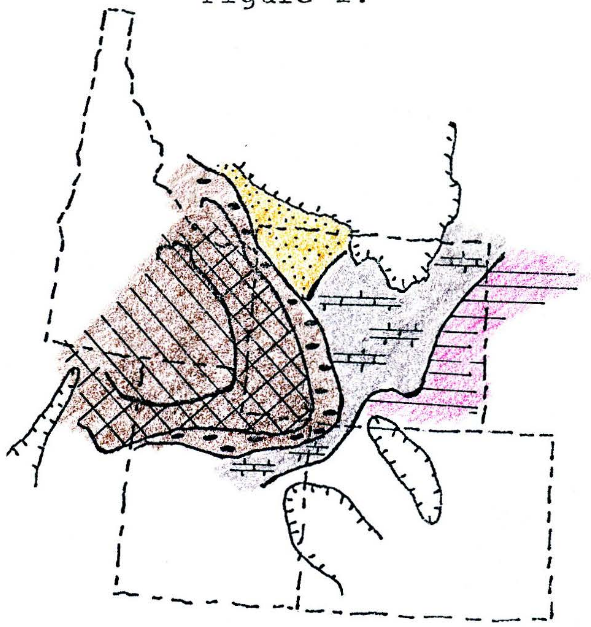
The Phosphoria, Park City, and Shedhorn Formations have each been divided into two or more members because of the striking changes in lithology and the intertonguing nature of the formations. A series of west to east transgressions of the sea deposited the repeated chemical sequence of rocks. The complete facies sequence from bottom to top is as follows: (1) red beds, (2) greenish-gray mudstone, (3) saline rocks, (4) light-colored carbonate rock and sandstone, (5) chert, (6) phosphorite, and (7) carbonaceous mudstone (McKelvey and others, 1959, p. 5). Phases (1), (2), and (3) of the cycle belong to the Goose Egg Formation which lies to the east of the Park City Formation. Phase (4) belongs to the Park City Formation or the Shedhorn Sandstone and Phases (6) and (7) belong to the chert and phosphatic shale members of the Phosphoria Formation (Sheldon, 1963, p. 124), (Fig. 1).

Thicknesses and lithofacies are related, the thickest units being the carbonaceous mudstone, phosphorite, and chert of the basinal facies, the thinnest being the light and red mudstone (Sheldon, 1963, p. 125). Identification of units from one place to another is difficult because the tonguing and lensing of units changes the vertical and lateral facies sequences of the rocks (McKelvey and others, 1959, p. 5). Many sections have been studied, yet it is found that the type section is still representative of the formation. It is located at Phosphoria Gulch, Bear Lake County, Idaho (McKelvey and others, 1959, p. 20).

Samples for this report were collected from previously measured sections at five localities: Tosi Creek, Wyoming (Sheldon, 1963, p. 200), Anchor Anticline, Wyoming and the nearby Embar section (Edwin K. Maughan, 1975), Mill Creek, Utah (Cheney), and Raymond Canyon, Wyoming (Figs. 2, 3, 4).

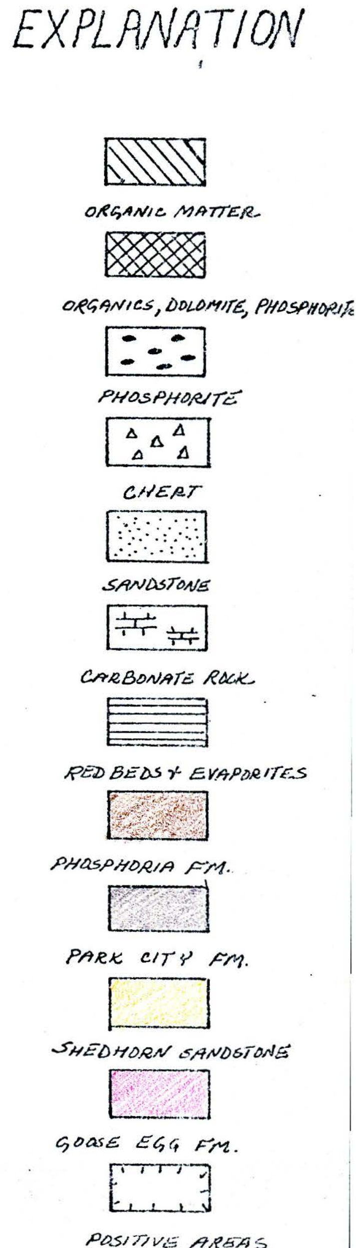
Because division of members and formational boundaries are defined solely on lithology, general descriptions of each member may be made without deference to locality.

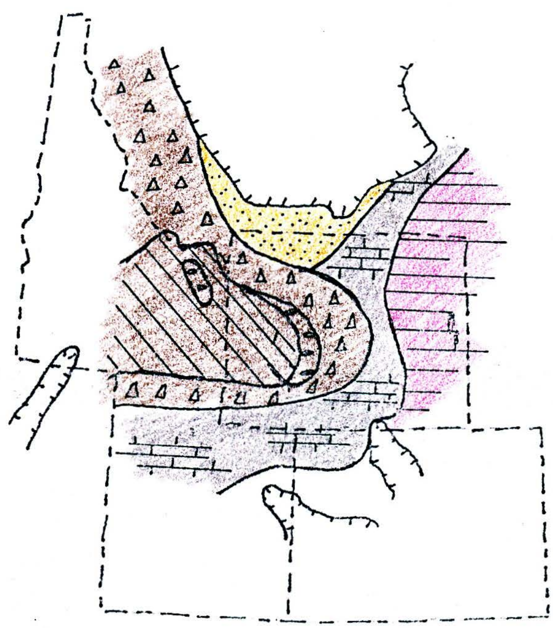
Figure 1.



Lithofacies of the first Permian

Transgression-- Late Artinskian Age



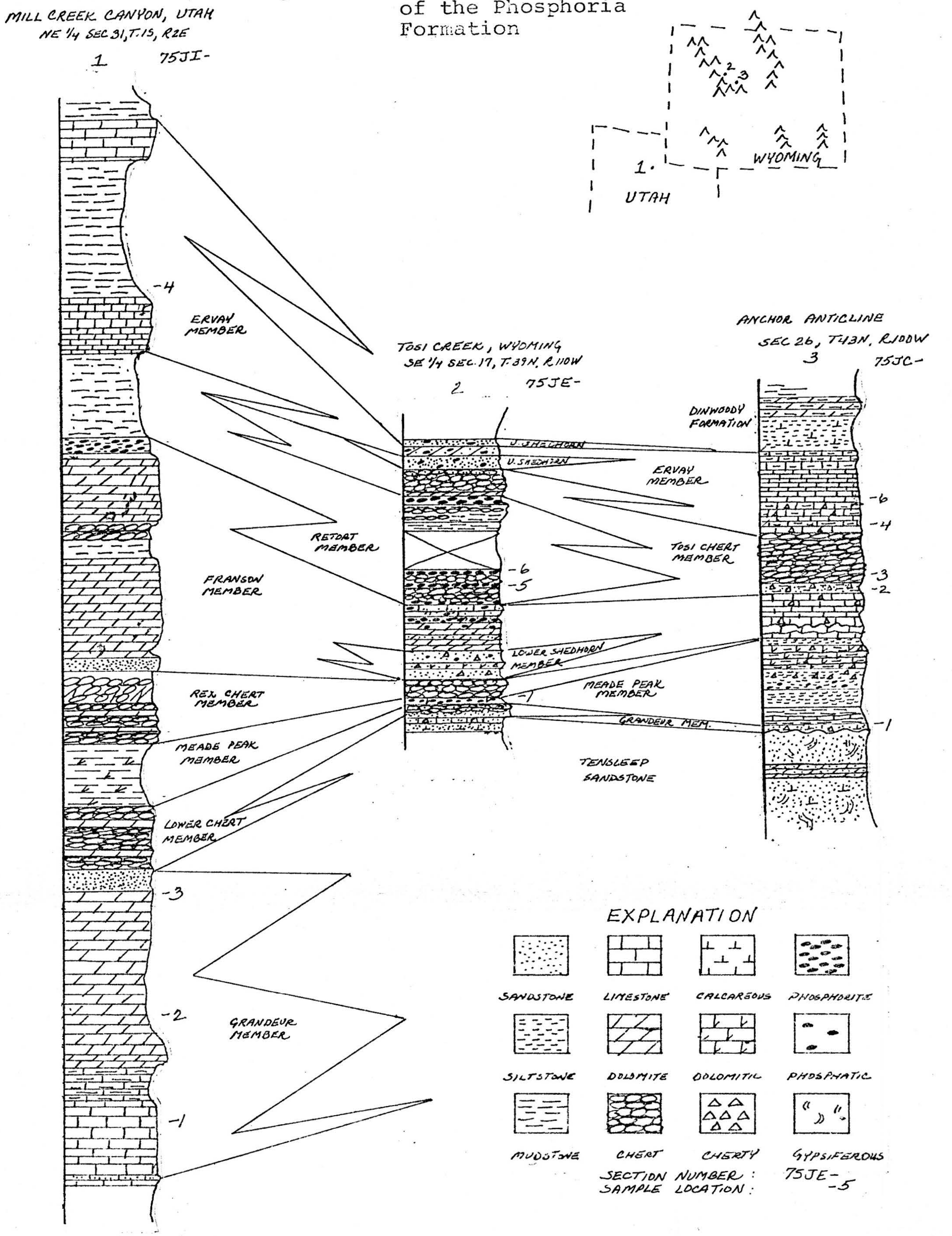


Lithofacies of the second Permian Transgression

Wordian Age

after McKEE, ORIEL, AND OTHERS 1967b

Figure 2. Stratigraphic Sections of the Phosphoria Formation



The basal member of the Phosphoria Formation is the lower chert member, a thin unit containing dark to medium-gray chert beds only. Above it lies the Meade Peak Phosphatic Shale Member, a non-resistant medium-gray to black sequence of bioclastic, pelletoidal and argillaceous phosphorite, mudstone, and carbonate rock. The overlying Rex Chert Member is pure, hard, thin-bedded to massive, dark to light gray and contains abundant siliceous sponge spicules, apatite in the form of bioclasts and pellets, and also lenses of bioclastic limestone. The Retort Phosphatic Shale Member overlies and is a non-resistant sequence of dark shale, phosphorite, mudstone, and argillaceous carbonate. At the top of the formation is the Tosi Chert Member, a hard, resistant, thin to thick-bedded dark gray chert (McKelvey and others, 1959; Sheldon, 1963).

The basal member of the Park City Formation, the Grandeur, intertongues with the lower chert and Meade Peak Members of the Phosphoria Formation. It consists of interbedded carbonate rock, cherty carbonate rock, calcareous sandstone and siltstone. The Grandeur Member is overlain by the Franson Member which intertongues with the Rex Chert, Retort, and Tosi Chert Members. The Franson Member is a hard, resistant unit of light gray to grayish-brown limestone, dolomite, cherty and sandy carbonate, mudstone, and calcareous sandstone. Limestone beds are composed of bryozoan, brachiopod, and echinoderm fragments, and granular bioclastic material with glauconite and phosphate.

Figure 3. Embar Section, Wyoming; Meade Peak Member contains red beds at this location. Note the relief of the more resistant limestone units.

Figure 4. Anchor Dam Section, Wyoming. Resistant units in the upper part of the section stand out distinctly.

The overlying Ervay Member is lithologically similar to the Franson Member and forms the top of the Park City Formation. This formation grades into the red beds and evaporite deposits of the Goose Egg Formation in central and eastern Wyoming to complete the facies cycle (McKelvey and others, 1959; Sheldon, 1963).

From the north the Shedhorn Sandstone intertongues with the Phosphoria and Park City Formations southward and eastward. The upper and lower members of the Shedhorn Formation are separated vertically by tongues of the Rex Chert, Retort, and Tosi Chert Members, and the Franson and Ervay Members. The sandstone is composed of fine to medium grained well-sorted quartz, is cross-bedded, and contains small amounts of phosphate chert, and glauconite (McKelvey and others, 1959, p. 32).

BIOSTRATIGRAPHY

Conodonts from the Phosphoria Formation were first reported by Branson and Branson (1941) from the Meade Peak Member in Wyoming. In 1951, Youngquist, Hawley, and Miller reported Phosphoria conodonts from southeast Idaho. No correlations were attempted in these early studies. Yochelson (1968, p. 622) correlated the Meade Peak Member to the Lower Franson Member, and the Retort Phosphatic Shale Member to the Upper Franson Member. He suggested

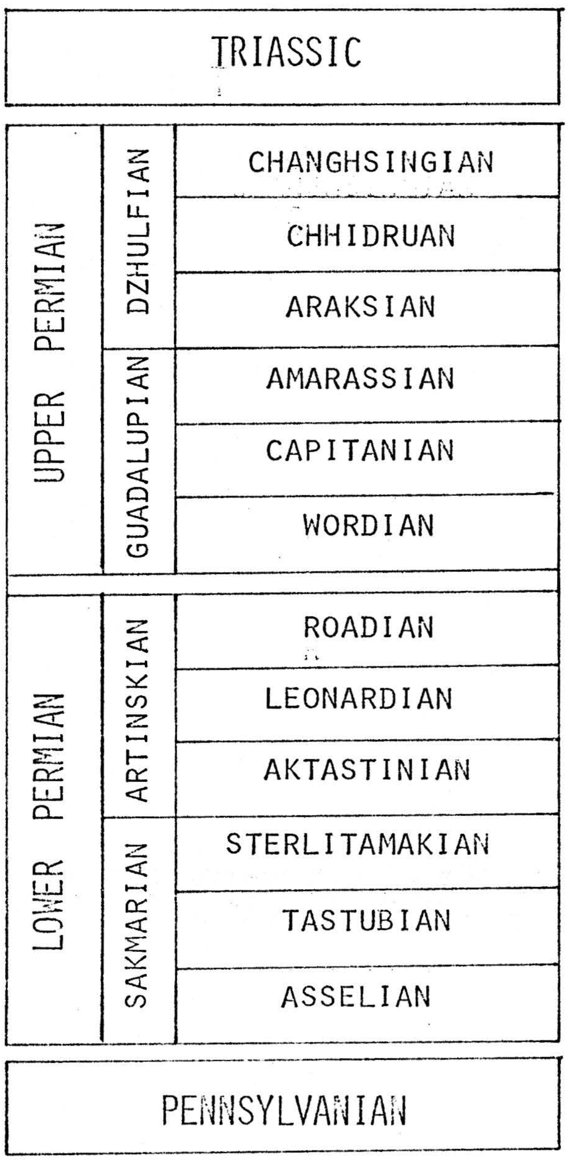
Late Leonardian to early Wordian as an oldest age for these units based on molluscan evidence, and Late Wordian as the youngest possible age based on brachiopod evidence. Furnish (1973, p. 534) in proposing a new stage classification for the Permian, noted that the Meade Peak Member belongs to the Roadian Stage (Fig. 5) on the basis of its ammonoid fauna.

Correlations and age determinations of the Phosphoria Formation based on Phosphoria conodonts alone have only been suggestive (Clark & Behnken, 1971; Behnken, 1975). Lack of complete conodont biostratigraphic studies of other Permian sections is the major hindering factor. Recently however, extensive Permian conodont studies have been undertaken by Marcantel (1975), Baird (1975), and Wardlaw and Collinson (in press), which begin to make these correlations possible.

In this study 665 conodont elements were found in samples from the Grandeur and Ervay Members of the Park City Formation and the Retort Phosphatic Shale Member of the Phosphoria Formation. Specimens represent the single element species *Neospathodus arcucristatus* (Clark & Behnken), *Neogondolella* cf. *N. gracilis* (Clark & Ethington), and most abundantly the multielement apparatus *Ellisonia* n. sp. (Marcantel, 1975). Examples of *Xaniognathus tribulosus* (Clark & Ethington) appear to be present in the Ervay and Retort Members but these elements are too few in number and too fragmented for positive identification. Conodonts from

Figure 5. Time-Stratigraphic

Subdivisions of the Permian



(after Furnish, 1973, p. 524)

all samples are broken or fragmented making identification difficult and for many elements impossible. However, the abundance of elements for the few species in the collection was a valuable aid in recognition.

Two samples of the Grandeur Member yielded a total of four conodonts, all believed to be elements of Ellisonia n. sp. This apparatus has a range from the upper-Lower Permian into the Triassic and therefore no correlation of the Grandeur has been attempted in this study. The Grandeur specimens collected at Mill Creek, Utah which are a dark gray color indicative of metamorphism by heating (Lindström, 1964) infer the possibility of a fault in the section.

Previous studies have assigned the Grandeur-Meade Peak interval a Late Leonardian Age (Roadian) on the basis of the Late Leonardian (Roadian) ammonoid Spirolegaceras (Nassichuk and others, 1965), and the presence of fauna of the Peniculauris bassi-Neostreptognathodus sulcoplicatus Zone, including N. sulcoplicatus (Wardlaw & Collinson, in press). The Grandeur was found to be equivalent to the upper type-Leonard Formation in West Texas and the Kaibab in northern Arizona on the basis of molluscan fauna (Yochelson, 1968).

All other specimens are from the Upper Phosphoria Retort Member and the Ervay Member of the Park City Formation. Both units yielded Neospathodus arcucristatus, Xaniognathus tribulosus, Ellisonia n. sp., and the Retort Member yielded two specimens of Neogondolella cf. N. gracilis. N. arcucristatus is the only one of these species with a presently known range useful for biostratigraphic correlation. It ranges from the Upper Plymptom Formation to the Lower to Middle Gerster Formation in eastern Nevada and western Utah (Marcantel, 1975).

The ranges of N. arcucristatus, Ellisonia n. sp., Neogondolella bitteri, and X. tribulosus overlap to form a distinct interval in the Lower Gerster Formation (Marcantel, 1974). The Retort Phosphatic Shale Member of the Phosphoria Formation is tentatively correlated with this interval on the basis of the presence of three of the four defining species, and the absence of Anchignathodus n. sp. and Neospathodus divergens (Bender & Stoppel) which define the Gerster intervals below and above, respectively. The Gerster Formation has been correlated by brachiopods to the type Word Formation in West Texas (Wardlaw, 1974); therefore, by the Upper Phosphoria-Gerster correlation of this study, a Wordian (Early Guadalupian) Age is assigned the Upper Phosphoria. This age is in agreement with studies by Yochelson (1968) and Sheldon and others (1967) in which the Phosphoria Formation was assigned an Early Guadalupian Age.

In the Wind River Range Yakovlevia multistriata (Meek) occurs in the upper-most Franson Member and lower-most Ervay Member of the Park City. East of this section, at Twin Creek near Lander, Wyoming Timaniella "pseudocameratus" occurs in the Retort Member. Wardlaw and Collinson (in press) have defined a zone, the Y. multistriata-Neogondolella bitteri Zone, which is characterized by the occurrence of these brachiopods. They have also found that *N. arcucristatus* ranges into the lower part of this zone. Occurrence of *T. "pseudocameratus"* and *N. arcucristatus* in the Retort Member and *Y. multistriata* just below indicates that the Retort Member in this study area correlates with the lower part of this *Y. multistriata- N. bitteri* Zone which is Late Wordian in age correlating with the Appel Ranch Member in West Texas (Wardlaw & Collinson, in press).

ENVIRONMENT OF DEPOSITION

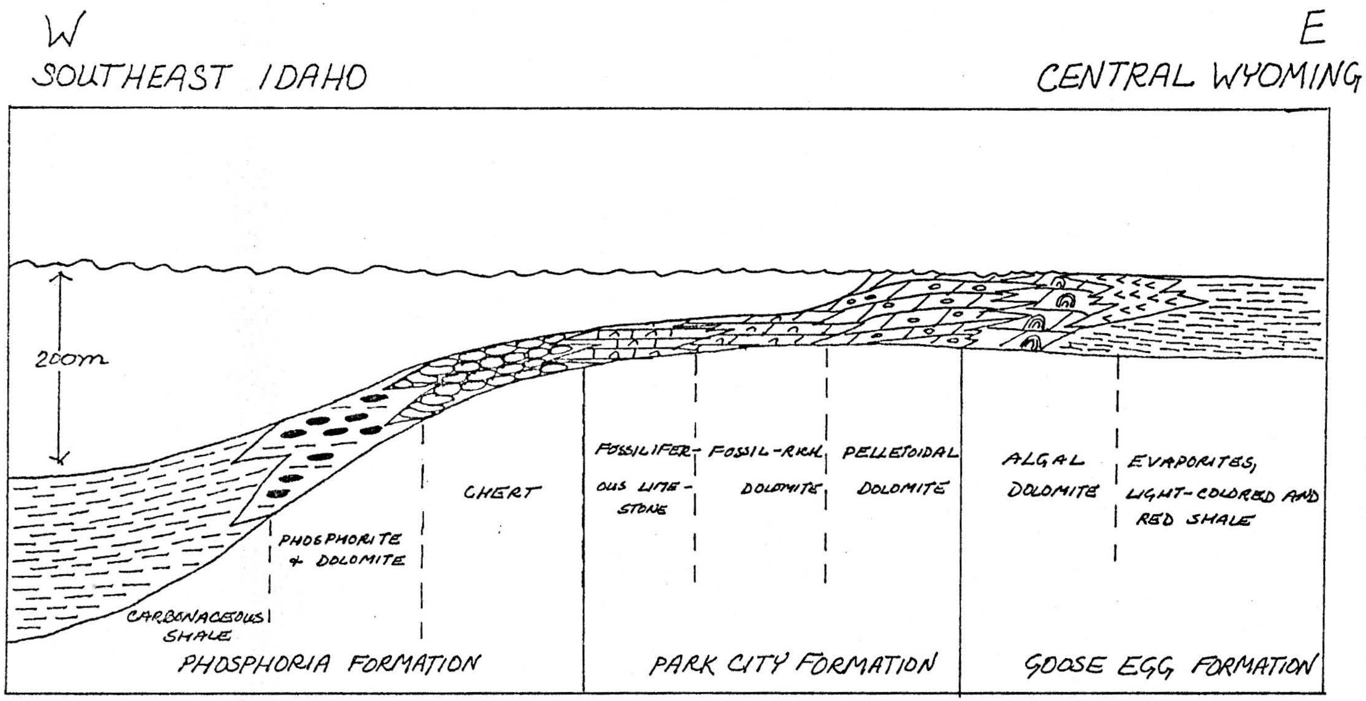
During the Permian Period the Phosphoria Sea was formed by an open embayment from the Pacific margin into southeast Idaho, northern Nevada, and western Wyoming. This embayment was flanked by broad shelves which extended northward into Montana and eastward into central Wyoming. The Phosphoria Formation was deposited in the basin and outer shelves, and the inner shelves received the clastic and carbonate deposits of the Park City Formation (Sheldon, 1963, p.147). In eastern Wyoming, the Dakotas, and Colorado, a sea with restricted circulation and perhaps a sabkha plain connected to the margin of the Phosphoria Sea by a narrow strait through central Wyoming (Maughan, 1975). To the north the embayment was confined by land masses in northern Idaho and Montana, and to the south by the Uncompahgre highlands and the ancestral front range. These land masses were low-lying as evidenced by the fine grain size and paucity of clastic sediments in the embayment. Western boundaries are generally believed to have been a volcanic arc on the west margin of the Cordilleran Geosyncline (McKee, 1967).

Cross beds in the Shedhorn Formation and the southward trending elongate geometry of this sandstone deposit indicates a southward current direction (Sheldon, 1963, p.145). The wind may have had a westerly component because few volcanic sediments are found in the Phosphoria or Park City Formations. These wind and current directions comply with the position of the Permian equator which passed just south of the study area on a northeast-southwest trend (Dott & Batten, 1971, p. 290).

A blanket of Pennsylvanian sandstone underlies most of the study area, tonguing westward into limestone. The sequence of Permian rocks records two major transgressive-regressive cycles. The first began during the Leonardian Age, depositing the Grandeur and Lower Franson Member of the Park City Formation, the lower chert, Meade Peak, and Rex Chert Members of the Phosphoria Formation, and the lower member of the Shedhorn Sandstone. During the second major transgression the Upper Franson and Ervay Members of the Park City Formation, the Retort and Tosi Chert Members of the Phosphoria Formation and the Upper Shedhorn Member were deposited. In this second cycle the facies are shifted farther to the north and the east (Sheldon, 1963, p.125), (Fig. 1).

The Meade Peak and Retort Phosphatic Shale Members of the Phosphoria Formation are believed to have been deposited at the peaks of the transgressions, and represent the deepest water deposits, which ~~appears~~ appear to have been no more than 200 meters. In the deepest part of the basin where reducing conditions existed, very fine detritus, carbonaceous matter, apatite modules, phosphorite, and many iron compounds including pyrite and glauconite accummulated. The phosphorite and chert were deposited farther in towards land, followed by the carbonates as the chemical factors of the water changed onto the shelves (Fig. 6). Many detailed studies of these chemical factors include those by Cheney (1957), Branson (1959), Sheldon (1963,1967), McKelvey and others (1953, 1959), and McKee and others (1967).

Ellisonia n. sp. and *N. arcucristatus* are the only species found in great abundance in this study, and were recovered from bioclastic limestones. These are shallow water species that appear to be tolerant of wide ranges of environments, excluding restricted super-saline conditions. The genera *Neogondolella* and *Xaniognathus* have been described as deeper water conodonts (Marcantel, 1975). These were recovered in small numbers from the Retort only, which is believed to represent the deepest water deposits of the collection from the Phosphoria Formation.



(from Sheldon, 1963, p. 159)

Figure 6. Ideal Sedimentation Sequence of the Phosphoria, Park City, and Goose Egg Formations.

SYSTEMATIC PALEONTOLOGY

All species of this study have been sufficently described in the recent literature to warrant omission of detailed descriptions of the elements. However, remarks are added when necessary and all forms are represented on Plate I for comparative purposes. E. Marcantel (1975) has classified *Ellisonia* n. sp. as a Type I apparatus of Klapper and Philip (1971). This study retains the use of this classification. Reference may be made to E. Marcantel (1975) for complete synonymies of *Ellisonia* n. sp. and *N. arcucristatus*.

Genus ELLISONIA Müller, 1956

Type Species: *Ellisonia triassica* Müller, 1956

Ellisonia n. sp.

Pl. 1, Figs. 2, 3, 5-9, 12, 13

This is a long ranging species, from the Lower Permian to the Early Triassic. It is characterized by robust peg-like denticles usually containing some white matter. There appears to exist a gradational variation in morphology within the species. Elements placed in synonymy with each element of Ellisonia n. sp. have been done so by examination of the other authors' materials or by a study of the original publications.

O element

Pl. 1, fig. 3

Ellisonia n. sp. O-element Marcantel, 1975, p. 101-102, Pl. 1, fig. 16.

Remarks: Specimens were identified from the other form transition elements by the differentiations suggested by Marcantel (1975, p. 102). This ozarkodiniform element is arched and has a sinuous basal margin, with the cavity flared under the cusp.

Repository: Figured hypotype: O. S. U. 31388.

N element

Pl. 1, fig. 5

Lonchodina müllери Clark & Ethington, 1962, p. 110-111, Pl. 1, fig. 4.

Lonchodina festiva Bender & Stoppel of Clark & Behnken, 1971, Pl. 2, fig. 9.

Ellisonia tribulosa Croft, 1972, p. 17-19, Pl. 2, figs. 15-17; Pl. 3, fig. 1.

Ellisonia festiva Sa_1 element of Baird, 1975, p. 31-32, Pl. 2, fig. 10.

Ellisonia n. sp. N element of Marcantel, 1975, p. 103-109, Pl. 1, fig. 23; Pl. 3, figs. 8,11,15,16,18.

Lonchodina inflata Bender & Stoppel, 1965, Pl. 16, fig. 18a,b,c.

Remarks: Twenty-five discrete elements were identified in the material of this study. Conclusive identification was made by studying the specimens of Marcantel (1975).

Repository: Figured hypotype: O.S.U. 31387.

A_1 element

Pl. 1, fig. 12, 13

Hindeodella triassica Müller of Bender & Stoppel, 1965, p. 343-344, Pl. 14, fig. 12; Pl. 15, figs. 3,4,5.

Roundya sp. a Bender & Stoppel, 1965, Pl. 15, fig. 19.

Hindeodella nevadensis Müller of Clark & Behnken, 1971, Pl. 2, fig. 13.

Ellisonia festiva Bender & Stoppel of Croft, 1972, p..15-17, Pl. 1, fig. 14; of Baird (S_c element), 1975, p. 33-34, Pl. 2, figs. 12, 16.

Ellisonia n. sp. A_1 element of Marcantel, 1975, p. 109-112, Pl. 1, fig. 22.

Remarks: All elements are broken, few have retained the anterior process. Lacks flaring cavity under cusp as in other elements. Some elements were distinctly arched whereas previously described specimens regarded the non-arched basal margin as characteristic of the species. Often lacks the white matter prevalent in the other elements of the _Ellisonia_ apparatus.

Repository: Figured hypotype: O.S.U. 31380.

A_2 element

Pl. 1, figs. 2,6,7

Ellisonia n. sp. A_2 element of Marcantel, 1975, p. 112-113, Pl. 1, figs. 18,21; Pl. 2, fig. 14.

Remarks: The distinct downward flexure of the anterior process and sharp downward hook at the distal end of the posterior process characterizes this element.

Repository: Figured hypotypes: O.S.U. 31382--31384.

A_3 element

Pl. 1, figs. 8,9

Roundya sp. b Bender & Stoppel, 1965, p. 350, Pl. 15, figs. 20a,b,c.

Ellisonia triassica Müller of Clark & Behnken, 1971, Pl. 2, fig. 4.

Ellisonia festiva Bender & Stoppel of Croft, 1972, p. 15-17, Pl. 1, fig. 15.

Ellisonia n. sp. A_3 element of Marcantel, 1975, p. 113-116, Pl. 1, figs. 17,20; Pl. 3, figs. 5-7, 10, 17.

Remarks: Four specimen were recovered, long posterior process is broken on all, identified by studying specimens of Marcantel (1975).

Repository: Figured hypotypes: O.S.U. 31385-31386.

Genus NEOGONDOLELLA Bender and Stoppel, 1965

Type Species: Gondolella mombergensis (Tatge), Bender and Stoppel, 1965.

Neogondolella cf. N. gracilis

Pl. 1, figs. 10,11

Gondolella gracilis n. sp. Clark & Ethington, 1962, p. 107, Pl. 2, figs. 6,10.

Remarks: Only two of these elements are present in the material of this study. Both are broken at the anterior end which makes identification difficult. The smooth narrow platform surface that is slightly upturned at the margins and the tapering of the platform at the antertior end of the carina make distinction between these elements and N. idahoensis difficult.

Repository: Figured hypotype: O.S.U. 31377

Genus NEOSPATHODUS Mosher, 1968

Type Species: Spathognathodus cristigalli Huckriede, 1958.

Neospathodus arcucristatus

Pl. 1, fig. 1, 4

Spathognathodus divergens n. sp. Bender & Stoppel, 1965, p. 350-351, Pl. 16, figs. 1-3, 21.

Neospathodus arcucristatus Clark & Behnken, 1971, pl 436, Pl. 2, figs. 1,2,5.

?Neospathodus divergens Clark & Behnken, 1971, p. 436-437, Pl. 2, fig. 6.

Neospathodus arcucristatus Behnden, 1975, p. 309, Pl. 2, fig. 8.

Neospathodus arcucristatus Marcantel, 1975, p.124-128, Pl. 1, figs. 14,19; Pl. 2, figs. 10, 12, 13.

Remarks: Thirty-nine specimens were recovered from the material of this study but are difficult to distinguish from N. divergens because all specimens are broken at the anterior and posterior. Denticles are broken and appear fused at the base. Few specimens show the two prominent larger denticles (cusp and denticle to the anterior) over the laterally flared basal cavity which serve to distinguish _N. arcucristatus_ from _N. divergens_. Flared basal cavity appears to be sub-triangular in shape. Results of this study suggest that _N. arcucristatus_ may be the unidentified P element of the _Ellisonia_ n. sp. apparatus by association, similar range, and a morphology which fits neatly into the form transition of _Ellisonia_ n. sp. (see Marcantel, 1975, p. 124-127).

Repository: Figured hypotypes: O.S.U. 31378-31379.

PLATE I

All figures are unretouched photographs of uncoated specimens X66, except figure 4 which is X53.

Figures

1, 4	<u>Neospathodus arcucristatus</u> Clark & Behnken. lateral views, 1=sample 75JC-2, O.S.U. 31378; 4=sample 75JD-1, O.S.U. 31379.
2, 3, 5-9 12, 13	<u>Ellisonia</u> n. sp. Marcantel. 2, 6, 7= lateral views of A_2 elements, sample 75JD-1, 2=O.S.U. 31382; 6=O.S.U. 31383; 7=O.S.U. 31384; 3=lateral view of O element, sample 75JD-1, O.S.U. 31388; 5=posterior view of N element, sample 75JD-1, O.S.U. 31387; 8, 9= A_3 element, 8=lateral view, sample 75JD-1, O.S.U. 31385; 9=posterior view, sample 75JD-1, O.S.U. 31386; 12,13=A_1 element, sample 75JD-1; lateral views, 12=O.S.U. 31380; 13=O.S.U. 31381.
10, 11	<u>Neogondolella</u> cf. <u>N. gracilis</u> Clark & Ethington. 10=oral view, 11=aboral view, sample 75JC-2, O.S.U. 31377.

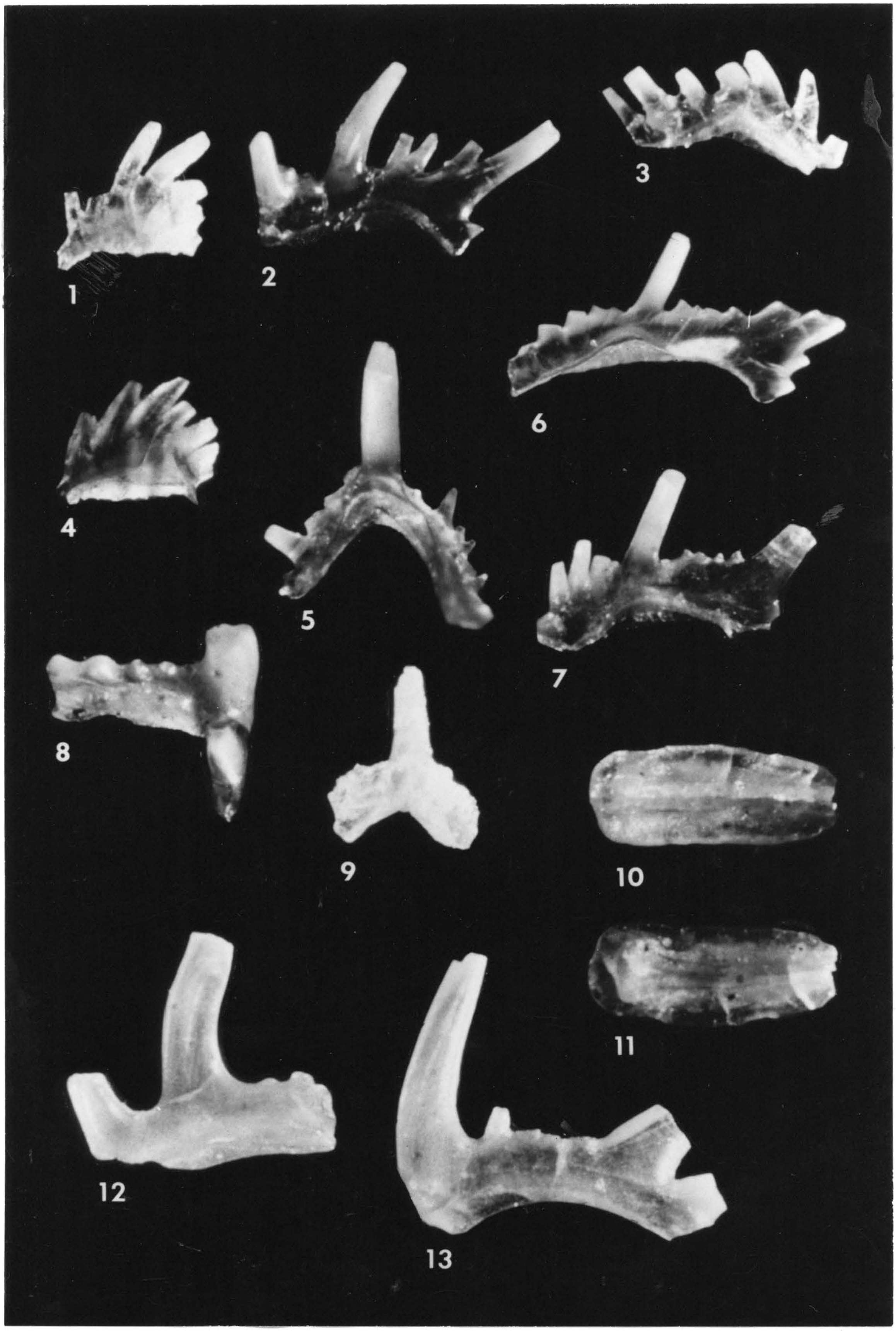


PLATE I

anterior and posterior. Denticles are broken and appear fused at the base. Few specimens show the two prominent larger denticles (cusp and denticle to the anterior) over the laterally flared basal cavity which serve to distinguish _N. arcucristatus_ from _N. divergens_. Flared basal cavity appears to be sub-triangular in shape. Results of this study suggest that _N. arcucristatus_ may be the unidentified P element of the _Ellisonia_ n. sp. apparatus by association, similar range, and a morphology which fits neatly into the form transition of _Ellisonia_ n. sp. (see Marcantel, 1975, p. 124-127).

Repository: Figured hypotypes: O.S.U. 31378-31379.

Page 27 not included with original paper copy.

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APPENDIX

Thin Section Descriptions Of Productive Samples

Ervay 75JC-6	Echinoderm -Bryozoan-Brachiopod-Packstone. Bioclasts are recrystallized; larger grains may have a sparry cement filling and are supported by a matrix of fine sand hash (echinoderm fragments (with syntaxial cement rims), trilobite, brachiopod, foraminifer, and pelecypod fragments). Scattered angular quartz grains and bioclastic phosphatic grains are present. Micritic cement in the matrix is aggrading to a microspar.
Ervay 75JI-4	Echinoderm -Bryozoan-Brachiopod-Packstone. Poorly sorted large bioclasts are micritically replaced brachiopods and bryozoan fragments; finer abraded clasts are dominated by echinoderm fragments with secondary syntaxial cement rims. Little silicification of the skeletal grains and few phosphatic grains present. A secondary dolomitic cement has formed in a matrix of organic material (stylolitic).
Retort 75JC-2 75JC-3 75JD-1	Packstone. These samples are organic- and phosphatic-rich limestones with a framework of brachiopod and bryozoan fragments. Cement is micritic to dolomitic. The large diagenetic dolomite rhombs have concentrated organic matter around the grain boundaries. Micrite and silica have replaced most of the calcium carbonate skeletal grains. Phosphate constitutes up to 25% of the sections in the form of pellets, skeletal fragments (original and by replacement), and as cement. Hematite, pyrite, and glauconite are minor constituents.

Grandeur 75JI-2	Wackestone to Packstone. Brachiopods and echinoderm fragments form the framework of the sample. Nearly all of this skeletal material is silicified; the matrix is a recrystallized cement of large dolomitic rhombs concentrating the abundant organic matter between the grain boundaries.
Grandeur 75JC-1	A well to meduim sorted, angular to subrounded quartz siltstone. Cement is a micritic calcium carbonate; large voids are filled with secondary coarse spar; pyrite altering to hematite is present in minor amounts.

TABLE 1

AGE OF THE SAMPLE	SAMPLE	GRAMS REDUCED	GRAMS UNDIGESTED	NEOGONDOLELLA CF. N. GRACILIS	NEOSPATHODUS ARCUCRISTATUS	ELLISONIA N. SP.					XANIOGNATHUS TRIBULOSUS (?)
						A_1	A_2	A_3	N	O	
Ervay	75JC-6	1000	10-	-	5	9	7	-	1	-	?
Member	75JI-4	1000	10+	-	-	?	-	-	-	-	-
Retort	75JC-2	1000	10-	2	11	33	6	-	7	10	?
Member	75JC-3	1000	10-	-	7	23	11	2	3	7	-
	75JD-1	2060	10-	-	16	57	12	2	14	11	?
Grandeur	75JC-1	1000	260+	-	-	-	-	-	-	?	-
Member	75JI-2	1000	1000-	-	-	?	-	?	-	-	-